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Specification

1 Invention title

Crystal Defect Examination Equipment

2. Scope of patent claims

A crystal defect examination equipment characterised by monitoring and displaying a sample (wafer) X-ray image as a specified multiple line integrated value, and an X-ray source to irradiate the sample with X-rays, and slits which regulate the X-rays in a microscopic width collimated beam, and an X-ray camera which outputs the X-rays passed through the sample received as a multiple scanning line electric signal, and a sampling stage which outputs an electrical signal of the specified multiple scanning lines from this X-ray camera as a digital signal of the specified number of pixels, and a movement stage in which the sample (wafer) is intermittently moved (by) one specified number of scanning line lengths of the above mentioned X-ray camera field of view for each of the specified multiple samplings, and an integration stage in which a digital signal obtained by sampling multiple lines at all pixels while stationary is integrated with a digital signal of all pixels after movement; being made to correspond with the sample positions, and a monitor which displays this integration value as an image of each position.

3. Detailed explanation of invention:
[Industrial based application area(s)]

This invention relates to ways of obtaining images by an X-ray camera from crystal defect examination equipment using X-rays, especially X-ray diffraction microscopy and such like.

[Prior art]

As witness the integration and miniaturisation of LSI, VLSI elements in recent years, we have made great progress, but the degree of perfection demanded in semiconductor materials has also increased enormously. So, how we can control the semiconductor crystal element lattice defects is becoming an extremely important problem, and the importance of semiconductor crystal defect examination is becoming ever greater.

Also, the use of quartz, lithium niobate (Li Nb O_3) etc., piezoelectric crystals is becoming indispensable where electronics engineering is concerned, so such means of crystal defect examination will also become extremely important.

Although various (methods) have been proposed in the past, as the means for examining internal defects of these kinds of electronics application crystals, among these it is well known that X-ray microscopy method is the most fundamental, and moreover most accurate method.

In this X-ray diffraction method, the X-rays emitted from the X-ray source 10 shown in Fig 2, are applied to the sample 16 by the micro-width collimated beam due to the first slit 12 and the second slit 14. The X-rays which are diffracted in the Bragg angle direction due to the sample 16 make a 90° angle of incidence with the X-ray detector comprising the third slit 18 and photographic plate 20 etc. At this point, the sample 16 and photographic plate 20 make a reciprocating motion in the same direction and in synchronism. Then, by repeating this reciprocating motion the X-rays may be counted (or integrated) on the surface of the photographic plate 20, and a clear diffraction image may be obtained over a wide range of the sample 16. Furthermore, with this reciprocating motion, while averaging out the uneven exposure due to temporal fluctuations of the X-rays, it isn't necessary for the X-ray output to be stable.

[The problem this invention aims to solve]

According to the above cited X-ray diffraction microscopy method, because high resolution X-ray diffraction images are obtained, the form of the electronics grade crystal lattice defects, and the types and position related information etc., may be understood.

However, in this X-ray diffraction microscopy method, since photographic plates may often be used, these need to be developed and printed, moreover, because high resolution photographic plates are in principle of low sensitivity, there was the problem of needing a long time before the examination results could be obtained. ie., to obtain photographs having adequate resolution, there was the problem of having to wait periods of typically over 10 hours.

This invention offers a crystal defect examination equipment capable of detecting crystal X-ray diffraction images efficiently and with high accuracy, whose aim is to resolve the points of issue as cited above.

[Steps to solve the problem]

The crystal defect examination equipment concerned in this invention is characterised in having an X-ray source to apply X-rays to the sample, slits to regulate the microscopic width collimated beam, an X-ray camera which receives the X-rays passed through the sample and outputs as a multiple horizontal line electrical signal, a sampling stage in which the specified multiple scanning line electrical signal is output from this X-ray camera as a digital signal of each of a specified number of pixels, a movement stage in which the sample is moved intermittently by a specified scanning line length increment of the above mentioned X-ray camera field of view for each of the specified multiple samplings, and an integration stage which integrates the digital signal obtained due to multiple sampling while stationary, with the digital signal of all pixels after the sample is moved, made to correspond with the sample position, possessing a monitor to display this integration result as an image for each position in the sample, thus providing a clear image using the sample X-ray multiple line integration values.

[The process]

Although the X-rays radiated from the X-ray source pass through the sample as a microscopic width collimated beam, the penetrating X-rays are stopped by the shielding plate, and are not radiated to the X-ray camera. Thus, the X-rays diffracted by this sample are incident upon the X-

ray camera and this X-ray camera outputs an electrical signal of each scanning line which has responded to the incident X-rays. The electrical signal output from the X-ray camera, which is sampled as a digital signal of each of the specified number of pixels, the sample being moved in synchronism with this sampling. At this point, the sample movement is done in pre-determined microscopic amounts, with data before and after movement being duplicated for the diffracted X-rays from the same sample position. In this way, a clear sample X-ray image may be obtained which shows the sample defect distribution as a specified multiple line integration value, by integrating the data before and after multiple line sampling.

[Implementation example]

One implementation example of this invention will be explained based upon a diagram for the said crystal defect examination equipment.

An X-ray source 10, employing a microfocussing X-ray tube, eg tube voltage 60 kV, 2kW unit, but was used at 50 kV with tube current below 10mA. Then, the X-rays emitted from this X-ray source 10 by dint of the first slit 12 and the second slit 14, fall incident upon the sample 16.

The X-rays reflected in the Bragg angle direction due to the sample 16, by dint of the third slit, 18, fall incident upon the X-ray camera which is sensitive to X-rays (X-ray Visicon). Here, in this example an X-ray camera 30, having 512 pixels in the horizontal direction and 512 lines in the vertical direction, was used. Then, the electrical signal from this X-ray camera 30 was input to an image processor 32.

This image processor 32 comprises a sampling section 34 and control section 36. Then the signals output from X-ray camera 30 are written into a sequential memory as digital signals in the sampling section 34. ie, signals corresponding to 512 x 512 pixels, which are input from the X-ray camera 30, are stored respectively in the first memory in the sampling section 34, as digital signals. Then, freeze commands from the control section 36 in each of the specified periods, act to send the data stored previously in memory 1 in the sampling section 34 to memory 2.

When inputting data not all of the 512 x 512 data from the X-ray camera 30 is necessary, the line lengths corresponding to the incident X-rays, or only one part of the scanning line direction responding to the target, will be effective. Because of this, the scanning lines determined in advance, eg 3 line lengths, are sent from the first memory in the sampling section 34 to the second memory.

Thus, the data sent from memory 1 in sampling section 34, eg, 3 line lengths of data concerning one line 512 data, are added and stored in memory 2. This operation is repeated for a pre-determined number of freeze commands, eg until data for 5 line lengths of data is completed. Then the data for 5 (freeze commands?) is supplied, and memory 2 integrates and retains internally the data for all the pixels.

In this way, when the pre-determined number of data samplings and adding is completed, the controller 36 will output a movement command to the motor controller 40 in the movement control section 38.

By driving the motor 42 based upon this command, the motor control 40 will move sample 16 in a direction perpendicular to the X-ray incident direction with slit 14, only by an amount equivalent to 1 line length scanning line width of the X-ray camera 30.

Due to this movement of the sample 16, of the 3 line lengths of data obtained by X-ray camera 30, 2 line lengths are duplicates of the previous data, so only 1 line length is renewed. Continuing in this way, the data for 5 freeze commands is adopted in the same way as previously, and this

is added and stored in sampling section 34 memory 2.

Regarding the 2 line lengths of duplicated data, because of the signal corresponding to the same position in the sample 16, these are sequentially integrated in corresponding memory locations. Due to one stationary freeze command, because data is duplicated 3 times on 5 occasions, data for 15 times will be integrated for one pixel, due to movement.

After completing line data integration 15 times, after the sample 16 is moved, one line is output to an external memory unit before integration is refreshed. Because of this, the whole X-ray diffraction image may be obtained sequentially in the form of these integration values, by moving the sample 16 in one line increments.

The X-ray diffraction image for the sample 16 obtained in this manner is displayed on monitor 44 according to the output from controller 36. Also, this result is output from controller 36 to floppy disc or hard disc etc., in an external memory unit 46.

Also, regarding the above cited example, the sample 16 is moved by 1 line length after this is repeated 5 times, obtaining 3 line lengths of information about X-ray camera 30.

However, these are not limiting conditions and depending upon the X-ray source 10, and the degree of perfection of the sample 16, these frequencies etc., may be changed accordingly. Furthermore, the pictures displayed on monitor 44 may be pictures of integrated data, or may be 3 lines of incremental data obtained by this intermittent sampling, but by changing a switch, these pictures may also be appropriately changed. Regarding this kind of implementation example, because of being able to integrate the image data as digital signals by the X-ray camera 30, the strength of the X-rays received at the X-ray camera 30 may be fairly low. Due to this, the time to obtain a suitable image can be shortened drastically.

Moreover, because the data obtained is saved as digital data, screen distortions on account of differences in the grating surface used in order to obtain the diffraction rays (line?), which inevitably arise, can be compensated for by pre-determined arithmetical calculations, and it is also possible to obtain screens having the same dimensions.

[Effectiveness of the invention]

In accordance with the above explanation, if based upon a crystal defect examination equipment according to this invention, an X-ray diffraction image can be obtained via a dry photographic process (electronically) by an X-ray camera, together with being able to reduce the time to obtain the image, and this data may be saved on a floppy disc as digital data.

4. Brief explanation of diagrams

Fig 1 shows the configuration of one implementation example of a crystal defect examination equipment according to this invention.

Fig 2 shows the configuration of a crystal defect examination equipment according to the prior art.

10...X-ray source

12, 14, 18....slits

16...sample (wafer)

30...X-ray camera

32...image processing section

34...sampling

36...controller

38...motion control section

40...motor controller

42...motor

44...monitor

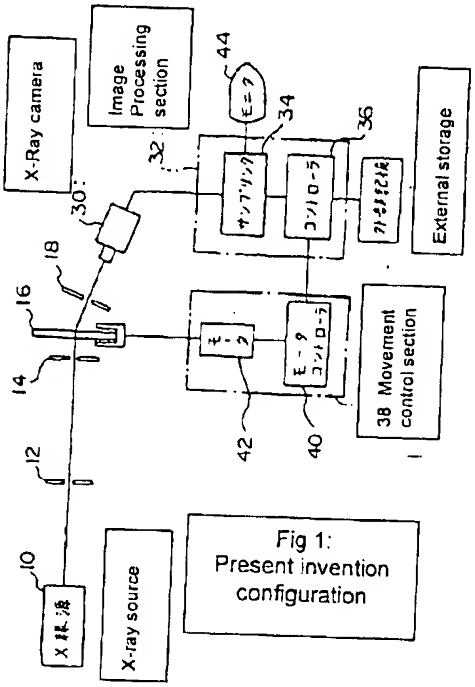

Fig 1:
Present invention
configuration

40 - Motor controller
42 - Motor
44 - Monitor
34 - Sampling
36 - Controller

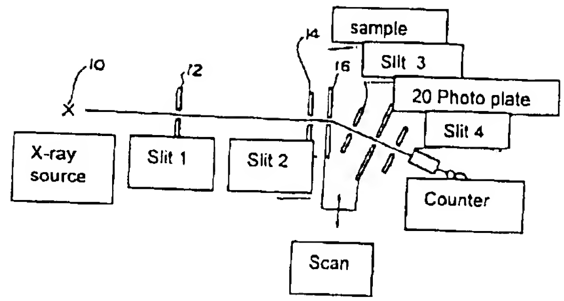

Fig 2: Prior art configuration